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SYSTEM AND METHOD FOR POSITIONING A PILE CAP UNDERNEATH AN EXISTING ELEVATED BRIDGE ASSEMBLY

by

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SYSTEM AND METHOD FOR POSITIONING A PILE CAP UNDERNEATH AN EXISTING ELEVATED BRIDGE ASSEMBLY

FIELD OF THE INVENTION

[0001] This invention relates generally to railroad bridges and more particularly to a system and method for positioning a pile cap underneath an existing elevated bridge assembly to upgrade the bridge assembly to support a rail assembly.

BACKGROUND OF THE INVENTION

[0002] Many existing wooden railroad bridges were built 70 or 80 years ago and are now in the process of being repaired because of deterioration or upgraded to handle the freight loads and speeds of modern trains. Most of the existing wooden railroad bridges are supported by wooden piles topped by wooden pile caps. The repair and upgrade of the bridges includes installing new steel beam piles and topping the new piles with pre-cast, concrete pile caps. Ultimately, the old, wooden piles and caps are removed, and new pre-cast, concrete spans, which are supported by the new caps and piles, are used to support the rail assembly.

[0003] A typical concrete pile cap is 17 feet long by three feet wide by three feet deep, and weighs 30,000 pounds. Currently, concrete pile caps are cast with lifting loops at each end so that the pile cap may be lowered straight down from the rail assembly onto the steel piles. This, however, requires that at least portions of all the stingers be removed and that both rails be cut and removed from the rail assembly. Train traffic is interrupted since the rail assembly is separated, and traffic cannot resume until the pile cap is placed on the steel piles and the rail assembly is restored.

[0004] It is preferred that upgrading the exiting wooden bridges is done with a minimum interruption of the train traffic. Windows of opportunity for performing the construction are seldom longer than six hours and frequently are as short as forty-five minutes. Current systems and methods in the art do not allow for minimum interruption.

[0005] The present invention is directed to overcoming, or at least reducing the effects of, one or more of the problems set forth above.

SUMMARY OF THE INVENTION

[0006] A system and method for positioning a pile cap underneath an existing bridge assembly disclosed. A portion of the rail assembly is removed to define an access area. At least three new piles are installed through the access area. The piles include a center pile and two opposing outer piles. Each pile has a proximal end and a distal end. The distal ends of each pile are driven into a support surface so that each pile generally extends from the support surface to the existing elevated rail assembly. The proximal ends of each pile are removed to define a gap between the piles and the existing elevated rail assembly. A new pile cap is then inserted into the gap. To insert the pile cap, a lifting device and a crane are used. The lifting device is used to incrementally insert the pile cap into the gap. The pile cap is supported on the piles and is used to support a new span for supporting the rail assembly.

[0007] The foregoing summary is not intended to summarize each potential embodiment, or every aspect of the invention disclosed herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The foregoing summary, a preferred embodiment, and other aspects of the present invention will be best understood with reference to a detailed description of specific embodiments of the invention, which follows, when read in conjunction with the accompanying drawings, in which:

FIG. 1 illustrates a perspective view of an existing bridge assembly having wooden piles and wooden pile caps;

FIG. 2A illustrates the bridge assembly being partially upgraded according to the present invention;

FIG. 2B illustrates a side view of the partially upgraded bridge assembly of FIG. 2A;

FIG. 3 illustrates a perspective view of the existing bridge assembly of FIG. 1 with a portion of the wooden ballast retainers and cross-ties removed according to the present invention;

FIG. 4 illustrates the bridge assembly with ballast boards removed according to the present invention;

FIG. 5 illustrates the bridge assembly with outboard non-load-bearing stringers removed according to the present invention.

FIG. 6 illustrates a new, center pile positioned through the assembly according to the present invention;

FIG. 7 illustrates the center pile, a first outer pile, and a second outer pile positioned through the assembly according to the present invention;

FIG. 8 illustrates a front view of proximal ends removed from the new piles to define a gap according to the present invention;

FIG. 9 illustrates a crane and a freight car positioned over the prepared portion of the assembly according to the present invention;

FIG. 10 illustrates a support bar being connected to a new pile cap according to the present invention;

FIG. 11 illustrates the crane lifting the pile cap out of the freight car according to the present invention;

FIG. 12 illustrates the crane lowering the pile cap adjacent the assembly according to the present invention;

FIG. 13 illustrates the crane rotating the pile cap to be perpendicular to the assembly according to the present invention;

FIGS. 14A-B illustrate the crane utilizing a first pair of lifting rods to position the pile cap to rest on two, new piles according to the present invention;

FIGS. 15A-B illustrate the crane positioning the pile cap further into the rail assembly utilizing a second pair of lifting rods with one of the lifting rods being located between the rails;

FIGS. 16A-B illustrate the crane positioning the pile cap further into the rail assembly utilizing a third pair of lifting rods with one of the lifting rods being located between the rails;

FIG. 17 illustrates the crane positioning the pile cap further into the rail assembly utilizing a fourth pair of lifting rods with one of the lifting rods being located between the rails;

FIGS. 18A-B illustrate the crane positioning the pile cap into a final position utilizing a fifth pair of lifting rods located outside of both rails;

FIG. 19 illustrates the crane placing the support bar into the freight car according to the present invention;

FIG. 20 illustrates an embodiment of a support bar in cross-section having lifting rods according to the present invention;

FIG. 21 illustrates an embodiment of a lifting rod according to the present invention;

FIG. 22A illustrates a perspective view of an embodiment of a pile cap according to the present invention;

FIG 22B is a cross sectional view of FIG 22A taken from line A-A; and

FIG. 23 illustrates a rope used to raise and lower a lifting rod according to the present invention.

[0009] While the invention is susceptible to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and will be described in detail herein. However, it should be understood that the invention is not intended to be limited to the particular forms disclosed. Rather, the invention is to cover all modifications, equivalents, and alternatives falling within the scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

[0010] FIG. 1 illustrates a portion of an existing bridge assembly 100 typically used to span a low elevational area, such as a valley, canyon, riverbed, or creek bed. The bridge assembly 100 includes an elevated rail assembly 102 supported by wooden pile caps 106 on wooden piles 104. The wooden piles 104 extend into a support surface or ground surface 108.

[0011] The rail assembly 102 includes first and second, parallel rails 114 and 16 used by railroad cars and engines. The rails 114 and 116 are supported on a plurality of cross-ties 118 along the length of the rails 114 and 116. The cross-ties 118 are supported on crushed stone ballast (not shown) and a plurality of ballast boards 122, which also extend

along the length of rails 114 and 116. The ballast boards 122 are fastened together by a plurality of side ballast retainers 120 located at each end of the ballast boards 122.

[0012] The ballast boards 122 are supported on a plurality of outboard non-load-bearing stringers 124 and load-bearing a plurality of stringers 126a-126e. The non-load-bearing stingers are located underneath and at the ends of the ballast boards 122. The plurality of load-bearing stringers 126a-126e is supported on the wooden pile caps 106. The stingers on bridge assemblies can have a number of configurations. In one configuration, for example, the stringers 126a-126e extend between adjacent, wooden caps 106 and are spaced approximately 18 inches apart in relation to each other with 126a being an inboard stringer and 126e being an outboard stringer.

[0013] Referring to FIGS. 2A-B, the existing, wooden bridge assembly 100 is illustrated partially upgraded according to the present invention. FIG. 2A illustrates a perspective view of the bridge assembly 100 showing only selected components, and FIG. 2B illustrates a side view of the bridge assembly 100 of FIG. 2A. Upgrading the existing, wooden bridge assembly 100 to handle the freight loads and speeds of modern trains involves replacing the existing wooden piles 104 with new piles 110, which are preferably made of steel, and replacing the existing wooden pile caps 106 with new pile caps 112, preferably made of pre-cast concrete. In addition, upgrading the wooden bridge assembly 100 involves replacing the exiting stingers 124 and 126 and ballast boards 122 with new spans 50, which are preferably pre-cast and made of concrete.

[0014] It is to be understood that FIGS. 2A-B do not necessarily represent how the bridge assembly 100 would appear during the process of upgrading the assembly according to the present invention. Rather, the partially upgraded bridge assembly 100 is presented to contrast the existing wooden structures (piles 104, caps 106, ballast boards, stingers 126, etc.) with the new structures (piles 110, caps 112, and spans 50) that are used to replace them.

[0015] Two sections 101a and 101b of the assembly 100 are shown for illustrative purposes. The first section 101a shows the exiting assembly 100 in an incomplete form. In the first section 101a, the rails 114 and 116 are shown supported on existing cross-ties

118, as best described above. For clarity, neither the crushed ballast nor the plurality of ballast boards is shown. For illustrative purposes, a part of the first section 101a is shown without the cross-ties, crushed ballast, and ballast boards so that the plurality of stringers 126 can be seen supported on the existing wooden caps 106 and piles 104.

[0016] In accordance with upgrading the bridge assembly 100, a new, concrete pile cap 112a is shown positioned underneath the stingers 126 between existing wooden pile caps 106b and 106c. This new, concrete pile cap 112a is supported on a plurality of new piles 110a. Preferably, the new piles 110a are steel H beams having a width of approximately 14 inches. The new piles 110a extend from the support surface 108 to the pile cap 112a. In the process of upgrading the bridge assembly 100 described in detail below, distal ends of the piles 110a are stabilized with the support surface or driven into the ground 108. Opposite, proximal ends of the piles 110a are eventually cut off to make room for the new pile cap 112a to be positioned below the exiting stingers 126.

[0017] To elucidate the system and method described in more detail below, the second section 101b of the assembly illustrates the desired result of the present invention. For illustrative purposes, the second section 101b is shown in an incomplete form. New piles and caps, such as piles 110b-c and caps 112b-c, are installed between every other wooden cap 106 and piles 104. In contrast to the conventional wooden piles 104 and caps 106 that are positioned every 15-feet along the assembly 100, the new piles 110b-c and caps 110b-c are positioned approximately every 30-feet along the assembly 100. After installing the new piles 110b-c and caps 112b-c under the existing stingers, the old, wooden components are removed. In particular, the old caps are removed, and the old, piles are removed or truncated, such as piles 105. Ultimately, the newly installed caps 112b-c and piles 110b-c support pre-cast, concrete spans 50a and 50b. The concrete spans 50a-b hold the ballast (not shown), cross-ties 118, and rails 114 and 116 of the rail assembly 102 and replace the old stingers and ballast boards.

[0018] The new pile caps 112 are approximately 34-inches in height, while the old wooden pile caps 106 are about 14-inches. As best shown in the side view of FIG. 2B, the top surface of the new pile caps 112 are set about three or four feet lower than the old

wooden pile caps 106. This allows for the approximately three feet depth of the pre-cast, concrete bridge spans 50 that will eventually be positioned on the new pile caps 112, such as the span 50b supported on caps 112b and 112c and piles 110b and 110c in the second section 101b. In addition, the position of the concrete piles 112 can include about another foot in depth to accommodate for ballast (not shown). The 30-inch deep span 50b replaces the 17-inch wood stingers 126 and the 3-inch wooden ballast boards (not shown).

[0019] With the benefit of the overview of the system and method according to the present invention described above, particular steps for positioning new piles and caps underneath an existing elevated bridge assembly to upgrade the assembly will now be discussed in more detail with reference to FIGS. 3-24. Referring to FIGS. 3 through 5, initial steps for creating an access area 128 in the assembly 100 according to the present invention are discussed and illustrated. Creation of the access area 128 allows new piles (not shown) to be installed through the rail assembly 102 and allows new pile caps (not shown) to be positioned on top of the new piles. In FIGS. 3-5 and in FIGS. 6-19 described below, the exiting wooden piles used to support the wooden caps 106 are not shown for simplicity.

[0020] FIG. 3 illustrates a first step in creating the access area. A plurality of cross-ties 118 is removed from underneath the rails 114 and 116. Side ballast retainers 120 adjacent the removed cross-ties are also removed from the both sides of the rail assembly 102. Although not shown, a three-foot section of crushed stone ballast is removed from the rail assembly 102 as well.

[0021] As illustrated in FIG. 4, ballast boards 122 are removed from underneath the rails 114 and 116 where the cross-ties 118 were previously removed. At this point, the stringers 126a-126e are exposed to view from the top of the rail assembly 102. As illustrated in FIG. 5, outboard, non-load-bearing stringers 124 are removed on both sides of the rail assembly 102. At this point, only the stringers 126a-126e span across the access area 128. A center stringer may also be removed if necessary.

[0022] As illustrated in FIG. 6, a center pile 130 is positioned between the rails 114 and 116, between a central pair of stringers 126, and through the access area 128. Alternatively, depending on the spacing of the stringers 126, a portion of one of the stringer may be cut away to make room for the center pile 130. A distal end 130_d of the pile 130 is then stabilized to a support surface 108. For example, the distal end 130_d is driven into the ground 108 "to refusal" so that the center pile 130 extends generally from the ground 108 to the existing elevated rail assembly 102. Alternatively, the distal end 130_d can be stabilized to another support or structure by methods known in the art. In the present embodiment, the pile 130 is preferably a steel H beam having a width of approximately 14 inches, but it will be appreciated that other support members or structures known in the art can be used.

[0023] As illustrated in FIG. 7, a first outer pile 132 and an opposing second outer pile 134 are then positioned through the access area 128. Distal ends 132_d and 134_d of each of the outer piles are driven into the ground 108. Each of the outer piles 132 and 134 generally extend from the ground surface 108 to the existing elevated rail assembly 102. Preferably, the two outer piles 132 and 134 extend from the ground surface 108 at convergent angles relative to the center pile 130.

[0024] Proximal ends 130_p, 132_p, and 134_p of each pile are horizontally cut off to define a generally uniform gap 136 between piles 130, 132, 134 and the rail assembly 102, as illustrated in FIG. 8. The ends 130_p, 132_p, and 134_p are cut with level tops to a precise height for welding to steel plates on the bottom of a new, pre-cast concrete pile cap (not shown). The proximal ends are cut immediately after the piles are driven into the ground surface 108 so that rail assembly 102 can continue to be used for rail traffic. In the present embodiment, the steel piles 130, 132, and 134 can be cut using a gas/oxygen flame at exactly the height where the cut end will be welded to the new caps. As noted above, it is understood that other members or structures can be used for the new piles. Thus, the step of horizontally cutting proximal ends of the piles may be unnecessary when the piles are not driven into the ground as described above, but are stabilized by other methods or structures.

[0025] At this point, the ballast, a substantial majority of cross-ties 118, and the rails 114 and 116 are still in place, and there are no obstacles to normal train traffic. The cross-ties that were removed to allow for driving the new piles can be replaced, and other cross-ties 118 approximately 30-feet away can be removed for driving the next set of piles.

[0026] Once the piles 110 are ready, a new, pile cap 112 of pre-cast concrete can be delivered by railroad car on the existing rail assembly 102, as illustrated in FIG. 9. A locomotive crane 138 is moved approximately over the access area 128. Coupled to the crane 138 is a freight car 144 housing the new pile cap 112. The crane 138 and freight car 144 are stopped in a position where the coupling (not shown) between the car 144 and crane 138 does not block the access area 128 from the top. The hand brake is set on the freight car 144, and the coupling is opened.

[0027] As shown in FIG. 10, the crane 138 is moved away from the car 144 to clear the coupling from the access area 128. The crane 138 has a boom 142 and a retractable cable 146. To lift and move the new pile cap 112, a lifting device is used. The lifting device includes an intermediate member or support bar 148 and a plurality of interconnecting members or lifting rods 150-160. Relevant details of the lifting device are provided below with reference to FIGS. 20, 21, and 23.

[0028] The cable 146 is connected to a center rod 152, which extends from the support bar 148 along with a first end lifting rod 150. The first end lifting rod 150 and the center lifting rod 152 define a first pair of lifting rods, which are both releasably connected to lifting points on the concrete pile cap 112. Relevant details of the pile cap 112 are provided below with reference to FIGS. 22A-B.

[0029] The lifting rods 150, 152 each have an extended position and a retracted position on the support bar 148. In FIG. 10, the first end-lifting rod 150 and the center-lifting rod 152 are shown in the extended position releasably connected to lifting points on the pile cap 112. A second end lifting rod 154, a first mid-portion lifting rod 156, a second mid-portion lifting rod 158, and a third mid-portion lifting rod 160 are shown in the retracted position on the support bar 148.

[0030] As will be further described below, each lifting rod corresponds to a lifting point or threaded hole in the pile cap 112 being approximately determined by the spacing of the stingers 126. The lifting rods each weigh approximately 90-lbs. and must be raised approximately eight feet when retracted on the support bar 148. To aid in the lifting of the rods, a double-sheave block is suspended from the crane arm to support two, one-inch diameter ropes. The ropes have eye splices at one end, which are slipped over the tops of the two active lifting rods. In a preferred embodiment shown in FIG. 23, a rope 137 is threaded through a sheave 139. The rope 137 has an eye splice 141 at the working end. It is slipped over the top of one of the lifting rods, for example 150. A pin 164 is placed through the top end of the lifting rod 150 so that the rope 137 may be used to raise and lower the lifting rod 150.

[0031] As shown in FIG. 11, the crane 138 lifts the pile cap 112 out of the freight car 144. The weight of the pile cap 112 is transferred through the center-lifting rod 152, while the first end lifting rod 150 helps to stabilize the pile cap 112. The pile cap 112 is lifted high enough to clear the side of the freight car 144 and is swung to the side of the rail assembly 102. The crane 138 preferably rotates approximately 20 degrees or less. The pile cap 112 is positioned parallel to the rails to decrease the required rotation of the crane and the resulting moment arm thereon.

[0032] As shown in FIG. 12, the crane 138 lowers the pile cap 112 adjacent the access area 128 to approximately a few inches, such as three inches, above the pile cap's intended final elevation. The crane 138 is then moved away from the access area 128 backward until the crane's lifting arc is directly over the center pile 130. The pile cap 112 is then rotated by a rope (not shown) attached to the first end lifting rod 150 until the pile cap 112 is generally perpendicular to the rail assembly 102, as shown in FIG. 13.

[0033] In this preferred embodiment, the locomotive crane 138 is used to lift and move the new concrete pile cap 112. It understood that attention must be made to the maximum moment arm on the crane 138, which can tend to overturn the crane as it holds the approximately 30,000-lb. pile cap 112 adjacent the rail assembly 102. While lowering the cap 112 adjacent the access area 128, the new cap 112 is preferably slightly

rotated to clear the existing wooden pile cap 106 at one end and to clear the edge of the bridge assembly at the other end. In this way, the maximum overturning moment arm can be limited to approximately 100-inches measured from the center of the rails 114 and 116 to the lifting cable 146.

[0034] If such a locomotive train is not used to move the pile cap adjacent the access area 128, then particular attention must be further paid to the maximum overturning moment arm. For example, in another embodiment, a crane can be carried in a freight car delivering the new pile caps. With a crane in a freight car, the limiting point of the overturning moment arm is a side bearing on top of a truck bolster of the freight car, which is only about 20 inches from an axial centerline of the rails 114 and 116. This imposes a severe limit on the load and or/ moment arm that can be handled without danger of overturning the crane and freight car. Accordingly, if other cranes, mechanisms, or methods are used in the art to lift and move the concrete pile caps, particular attention must be paid to the overturning moment. It will be appreciated by one of ordinary skill in the art, however, that a number of cranes, methods, and mechanisms are known in the art for providing an increased maximum moment arm to resist overturning.

[0035] As shown in FIGS. 14A-B, the crane 138 positions one end of the pile cap 112 partially into the access area 128 and gap 136 from the side of the rail assembly until the center lifting rod 152 is adjacent to or in contact with the outboard stringer 126a. At this position, an additional lifting point on the pile cap 112 that is approximately 60 inches from the center is visible through the access area 128. As shown in FIG. 14B, the cable of the crane 146 can include a hook or other connector 147 connected to one end of the center lifting rod 152.

[0036] As shown in FIGS. 15A-B, the crane 138 lowers the pile cap 112 onto at least two piles, such as the center pile 130 and the first outer pile 132. The weight of the pile cap 112 is thereby taken off the lifting rods. The first mid-portion lifting rod 156 is extended from the support bar 148 and is releasably connected to the lifting position of the pile cap 112 visible through the access area 128. The center lifting rod 152 is

disconnected from the pile cap 112 and is retracted up into the support bar 148, as best shown in the end view of FIG. 15B. Thus, at least two lifting rods are preferably connected to the pile cap 112 when alternating the interconnection of the rods with the pile cap. The center lifting rod 152 and the first mid-portion lifting rod 156 define a second pair of lifting rods extending from the support bar 148. The first end lifting rod 150 stabilizes the pile cap 112, while the center lifting rod 152 is retracted from support bar 148 and the first mid-portion lifting pipe 156 is releasably connected to the pile cap 112.

[0037] The crane 138 then lifts the pile cap 112 off the center pile 130 and the first outer pile 132. The crane 138 further positions the pile cap 112 into gap 136 by moving the center of the pile cap 112 approximately 18-inches closer to the center of the rail assembly 102. At this position, an additional lifting point on the pile cap 112 that is approximately 42 inches from the center is visible through the access area 128. The pile cap 112 is then lowered to rest on at least two of the piles, such as center pile 130 and first outer pile 132.

[0038] The second mid-portion lifting rod 158 is extended from the support bar 148 and is releasably connected to the pile cap 112, as best shown in the end view of FIG. 16B. The first mid-portion lifting rod 156 is then disconnected from the pile cap 112 and retracted from the support bar 148. The second mid-portion lifting rod 158 and the first end lifting rod 150 define a third pair of lifting rods extending from the support bar 148. The crane 138 then lifts the pile cap 112 off the center pile 130 and the first outer pile 132.

[0039] The crane 138 further positions the pile cap into the gap 136 an additional 18 inches toward the center until the second mid-portion lifting rod 158 is adjacent to or in contact with stringer 126c. At this point, an additional lifting point on the pile cap 24 inches from the center of the cap is visible through the access area 128. The pile cap 112 is then lowered to rest upon two piles, such as center pile 130 and first outer pile 132.

[0040] As illustrated in FIG. 17, the third mid-portion lifting rod 160 is extended from the support bar 148 and is releasably connected to the pile cap 112. The second mid-

portion lifting rod 158 is disconnected from the pile cap 112 and retracted from the support bar 148. The third mid-portion lifting rod 160 and the first end-lifting rod 150 define a fourth pair of lifting rods.

[0041] The crane 138 then lifts the pile cap 112 off the center pile 130 and outer pile 132. The crane 138 further positions the pile cap 112 into the gap 136 an additional 18-inches until the third mid-portion lifting rod 160 is adjacent to or in contact with the next stringer 126d. At this point, an outboard lifting point in the pile cap 112 is visible beyond the outboard stringer 126e. The pile cap is then lowered to rest upon piles 130, 132, and 134.

[0042] As illustrated in FIGS. 18A-B, the second end lifting rod 154 is then extended from the support bar 148 and is releasably connected to the pile cap 112. The second end-lifting rod 154 and the first end-lifting rod 150 define a fifth pair of lifting rods. Then, the third mid-portion lifting rod 160 is disconnected from the pile cap 112 and retracted from the support bar 148. The crane 138 then lifts the pile cap 112 off piles 130, 132, and 134. The crane 138 further positions the pile cap 112 into the gap 136 so that the pile cap 112 is centered directly under the rail assembly 102. The pile cap 112 is then lowered onto piles 130, 132, and 134 so that the weight of the pile cap 112 is taken off the fifth pair of lifting rods 150 and 154.

[0043] The pile cap 112 includes three steel plates (not shown) that are cast and anchored into a bottom surface of the pile cap 112. These steel plates correspond to the spacing of the piles 130, 132, and 134. The pile cap 112 is welded at the juncture of the steel plates and the piles 130, 132, and 134. The first end lifting rod 150 and the second end lifting rod 154 are then disconnected from the pile cap 112 and retracted from the support bar 148. The crane 138 then lifts the support bar 148 and the lifting rods back into the freight car 144, as illustrated in FIG. 19.

[0044] With the new cap 112 and piles 130, 132, and 134 installed, the above system and method according to the present invention can be repeated at further locations along the bridge assembly. As discussed above, new caps and piles are positioned between every other wooden cap and piles or about every 30-feet along the bridge assembly.

Once the new caps and piles are installed below the exiting bridge assembly, the old, wooden caps, piles, and ballast can be removed.

[0045] In practice of the present invention, it is understood that all the steps discussed above need to be preformed at one location at one time on the bridge assembly 100. Instead, it is preferred that at least some of the steps be performed along the length of the assembly 100 before further steps are performed. For example, creating the access area, driving the new piles, cutting the new piles, and positioning the new caps on the piles can be performed at one location and then further locations along the assembly before the wooden caps and piles are replaced with new, concrete spans. As evidenced herein, the system and method according to the present invention advantageously maintains a substantial portion of the load-bearing components of the rail and bridge assembly and allows the exiting rails and bridge assembly to be used while performing the steps in this manner.

[0046] FIG. 20 illustrates an embodiment of a lifting device according the present invention. The lifting device includes an intermediate member or support bar 148 and a plurality of interconnecting members or lifting rods 150-160. The support bar 148 is illustrated in cross-section to show an internal hollow defined therein. The support bar 148 defines a plurality of first or top apertures 161a from a top of the bar to the internal hollow. The support bar 148 defines a plurality of equally located, second or bottom apertures 161b from a bottom of the beam to the internal hollow. The bottom apertures 161b have a greater dimension than the top apertures 161a.

[0047] The lifting rods 150-160 are disposed in the plurality of apertures 161a-b in the support bar 148. The apertures 161a-b are approximately spaced to cooperate with the spacing of the stringers of the rail assembly and with the spacing of the lifting points on the new pile cap. For example, the first mid-portion lifting rod 156 is preferably spaced approximately 60 inches from the center-lifting rod 152. Also, the second mid-portion lifting rod 158 is preferably spaced approximately 42 inches from the center lifting rod 152, and the third mid-portion lifting rod 160 is preferably spaced approximately 24 inches from the center lifting rod 152. This spacing accommodates the typical spacing of

stringers in a rail assembly, although it is understood that other arrangements of spacing may also be applicable to the present invention. In an alternative embodiment, three additional lifting rods (not shown) can be located between the center lifting rod 152 and the first end lifting rod 150. The spacing of the three, additional lifting rods can be similar to the first, second, and third mid-portion lifting rods from the center.

[0048] The first end lifting rod 150 and the second end lifting rod 154 are shown in the extended position in relation to the support bar 148. The center lifting rod 152, the first mid-portion lifting rod 156, the second mid-portion lifting rod 158, and the third mid-portion lifting rod 160 are all shown in the retracted position. Removable pins 164 are used to hold the rods in the retracted position. Preferably, all of the lifting rods can be retracted so that a threaded end can be housed in the internal hollow of the support bar, which protects the threads from damage when not in use.

[0049] The center-lifting rod 152 is movably disposed in central apertures of the support bar 148 between extended and retracted positions. The center-lifting rod 152 has a lower end capable of releasably connecting to the cap at one of the lifting points when in the extended position (not shown). The lower end is also capable of engaging the inner hollow of the support bar 148 adjacent the upper aperture 161a when in the retracted position as shown in FIG. 20. The center-lifting rod 152 also has an upper end capable of connecting to the cable. In one embodiment, the center-lifting rod 152 includes a swivel and shackle 162 so that the cable of the crane can be attached to the center-lifting rod 152. The upper end is also capable of engaging the outer surface of the support bar 148 adjacent the upper aperture 161a when in the extended position (not shown).

[0050] The plurality of other lifting rods 150, 154, 156, 158, and 160 are also movably disposed in the apertures 161a-b of the support beam between extended and retracted positions. These rods have a lower capable of releasably connecting to the cap at one of the lifting points when in the extended position. These rods also have an upper end capable of engaging outside surface of the support beam adjacent the upper aperture 161a when in the extended position, such as rods 150 and 154 are shown in FIG. 20.

[0051] FIG. 21 illustrates an embodiment of a lifting rod according to the present invention. Shown by way of example is a first end lifting rod 150 with an upper collar 166 at an upper end of the lifting rod and a large diameter area 168 at a lower end of the lifting rod. The upper collar 166, which may be welded to the rod, is a stop to keep the lifting rod 150 from sliding out of the support bar when the pile cap is being lifted. Adjacent to the large diameter area 168 is a male member or tapered threaded section 170 for releasably connecting to the cap. The lifting rod 150 further includes an aperture 172 for a pin, such as the pin 164 in FIG. 20, to hold the rod 150 in the retracted position in the support bar. The lifting rod also includes another aperture 173 receiving the pin to retract and extend the rod in the support bar. The male member 170 on the rod 150 can be threaded to a lifting point on the pile cap by a hydraulic motor on the crane under the remote operation of the operator.

[0052] FIGS. 22A-B illustrate an embodiment of a pile cap 112 according to the present invention. The pile cap 112 includes a plurality of lifting points or threaded holes 174, 176, 178, 180, 182, and 184 used for the lifting rods. The lifting points are positioned along a longitudinal axis of the pile cap 112. In particular, the pile cap 112 includes a first outboard-threaded hole 174 and a center threaded hole 176 at the center of the pile cap 112. Opposite the outboard-threaded hole 174 is a second outboard-threaded hole 178. Spaced apart between the center threaded hole 176 and the outboard-threaded hole 178 is a first threaded hole 180, a second threaded hole 182, and a third threaded hole 184. The threaded holes on the pile cap 112 are spaced to match the spacing of the lifting rods spaced across the support bar 148.

[0053] The releasable connection between the threaded holes and the lifting rods is made by mating the threads of the lifting rods with the appropriate threaded hole of the pile cap 112. The load bearing surface 186 is adapted to support new pre-cast concrete bridge spans, which in turn support the existing elevated rail assembly. The pile cap 112 can further include three additional threaded holes located between the center-threaded hole 176 and the inboard-threaded hole 174 so that the pile cap 112 is symmetrical about the center.

[0054] Past attempts of providing the lifting points or threaded holes in the pile cap 112 involved welding threaded steel nuts to reinforcing steel that was then cast in the material of the cap. It has been found that the heavy load of the pile cap striped the threads of the welded nuts. Thus, as best shown in FIG. 22B, the threaded holes 174, 176, 178, 180, 182, and 184 according to the present invention are preferably formed from cut lengths of oil well drilling pipe 190. The pipes 190 are attached to reinforcing steel 188 and then cast into the concrete when the cap 112 is formed. The oil well drilling pipe 190 is internally threaded and is flush with the load bearing surface 186 of the cap 112. The flush ends of the pipe 190 will not interfere with the new, pre-cast concrete spans to be supported on the load bearing surface 186.

[0055] The threaded holes 174, 176, 178, 180, 182, and 184 are tapered to provide automatic alignment with the threaded section of the lifting rods, such as section 170 in FIG. 21. The threads are very coarse so that only a few turns of the lifting rod is required to make the releasable connection. As is known in the art, the threads of the oil well drilling pipe 190 are designed to support thousands of feet of interconnected drill pipe, which can impose loads of 100,000-lbs. or more on couplings of the upper pipes. This is many times the weight of the pile cap 112 to be lifted. As discussed above, at least two lifting rods are releasably connected to the lifting points on the cap 112. Thus, the internal threads of two pipes 190 are adequately capable of sustaining the approximately 30,000-lbs. load of the pile cap 12 when coupled to at least two lifting rods.

[0056] Preferably, the pile cap 112 has a reinforcement bar 188 extending through the threaded oil well drilling pipes 190. Prior to the pile cap 112 being cast with concrete, holes are drilled in the oil well drilling pipes 190 for interconnecting the reinforcement bar 188 with the pipes 190. The reinforcement bar 188 is preferably steel re-bar and is preferably disposed through the holes in the pipes 190 and not welded to them. The reinforcement bar 188 helps to retain the pipes 190 in the pile cap 112 when lifted. As at the tops of the pipes, the lower ends of the pipes 190 are flush with the bottom of the pile cap 112. In addition, the bottom ends of the pipes 190 are open, and the pipes 190 are able to drain rain water.

[0057] While the invention has been described with reference to the preferred embodiments, obvious modifications and alterations are possible by those skilled in the related art. Therefore, it is intended that the invention include all such modifications and alterations to the full extent that they come within the scope of the following claims or the equivalents thereof.